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SCIENCE AND SERVICE[1]

THE service of science to humanity was initiated when the early philosophers began to discover and record the more simple truths of nature. Then, as now, the "sciosophists," defined by David Starr Jordan as "apostles of systematized ignorance," rejected all evidence without attempting to prove or disprove, and condemned the exceptional mind that was compelled by an inner urge to attempt to penetrate into the mists that concealed the unknown.

Through many centuries human thought was confined largely to channels predetermined by the religious and political concepts of the more intelligent. To this privileged group freedom of expression by others was intolerable, and a seeker after truth other than that provided and established by authority was fair game to be hunted down and destroyed. Progress came as an undercurrent of truth that slowly gathered strength and volume, until, like the warm waters of tropical ocean currents penetrating the colder regions, it weakened the congealed crust of ignorance and prejudice, and, combining with the sunshine of scientific research, gradually dispersed systematic opposition to the growing appreciation of natural phenomena and laws.

The story of the onward march of scientific research in quest of truth is not unlike that of the white race in the conquest of America. A few fearless souls penetrated the wilderness and blazed the trails that others might follow; some fell martyrs to their zeal, but more came after; facts were determined, laws established, which in time contributed to the welfare of the race.

Science has made great progress, but its conquest of the unknown and of the unprogressive doctrines of the sciosophists is still far from complete. When we consider the many vital problems that are being discussed and the indifference and limited training of a large proportion of supposedly intelligent people, it seems only well under way. The search for truth and the interpretation of facts and their verification and application must continue, with ever-enlarging conceptions until the ultimate destiny of our race is fulfilled.

Millikan has well said: "The purpose of science is to develop without prejudice or preconception of any kind a knowledge of the facts, the laws and the processes of Nature." The search for truth based on this scientific method is one of the greatest inspirations and incentives to high and thorough endeavor. The

[1] Address of the retiring president of the American Association for the Advancement of Science, Washington, D. C., December 29, 1924.

searcher may be engaged in any field of human knowledge, including religion, history, literature, natural science or government; his motive may be of the highest type of pure delight in investigation and discovery for the sake of truth, or it may be sordid and egotistic; but his results, after being subjected to the exacting tests of general discussion and criticism, will find their place in the general scheme of the advancement of the physical, mental and spiritual well-being of man.

The scientist need not enter into controversies with the theologian or the sciosophist. He may make mistakes and interpret nature incorrectly, and he will never become so infallible or omniscient as to be sure that he has the entire or exact truth, but, as in the past, he may add a little here and a little there, until a great inspired mind grasps the multitude of facts and interprets from them a fundamental general law of nature. A structure of theory or hypothesis is then reared that may endure for a generation or two, until a continually growing knowledge requires some modification that may strengthen it, or lead to its partial or complete rejection.

An illustration of work to be done by the specialist may be drawn from my own investigations relating to primitive life. In 1876 I spent a month tracing the distribution of the "Potsdam Sandstone" about the Adirondack Mountains of New York, and in collecting fossils from the sandstone and the immediate superjacent Hoyt limestones. I was told the following winter by the geological authorities of the day that there was little use of attempting to discover traces of life in rocks lower than the Potsdam, as they rested upon the Archean. During the forty-eight years that have passed since then I have always had in view the discovery of older and still older evidences of primitive life. The Upper, Middle and Lower Cambrian faunas were all found in orderly succession beneath the Potsdam, and finally bacteria and algal deposits far below in the pre-Cambrian. Sixteen years ago I discovered a locality in the lower Middle Cambrian Burgess shale of the Canadian Rockies in which the fossils were marvelously preserved. This deposit yielded a wonderful series of marine invertebrates showing clearly that at this early time the evolution of the life in the sea had progressed far beyond our previous conceptions of it, and that, with the exception of the cephalopods and vertebrates, there has been very little development in the classes of animal life during the millions of years between the time of the Burgess shale fauna and the present. Recently there have come to light fossils in the upper portion of the Lower Cambrian that indicate that the types of the Burgess shale fauna were then in existence.

Beneath the Lower Cambrian on all the continents there is a great unconformity between the basal beds and the superjacent pre-Cambrian formations that have been grouped in the Proterozoic and Archeozoic eras. Although we have found traces of bacteria and algal growth in the Proterozoic, it is not considered that these forms were the progenitors of the Cambrian faunas. In fact, the search for primitive pre-Cambrian evidences of life other than that which may have existed in fresh water lakes and streams has come to a standstill at the great unconformities beneath the Cambrian and the Proterozoic. I do not know of a trace of the great primal marine life of the ocean basins from which the Cambrian faunas are descendent, except the few fragments that have been found in the Proterozoic; nor have we found evidence of the deposits of undoubted marine sediments on the present land areas that are older than those of the lower Cambrian. This leaves the field open for the research student of the future to discover the earlier forms of life that in a slow evolution through millions of years finally developed into the highly organized invertebrates of early Cambrian time.

Research students in all branches of scientific endeavor soon discover that with every accession of knowledge new problems open up that will demand attention and effort for years to come. I recall full well as a young man consulting with older scientists and getting the impression that they thought a large proportion of the great scientific problems had been settled; and they often denounced most bitterly the younger men who dared to question the accepted conclusions of their scientific studies.

The sciosophists will rail at and denounce the scientific method, as he can not or will not comprehend it, but it is clearly the only method by which the errors of the present and truth of the future may with certainty become known. "Beyond the conclusion reached through competent study of nature and natural law by cautious and highly trained investigators, it is not possible for any one to go, except as the searcher after truth himself pushes further ahead in his quest."

Such a broad organization as the American Association for the Advancement of Science must consider ways and means by which it may do its part in the great readjustments of thought and action constantly going on, which will aid or obstruct the advance of mankind towards a more just and ever finer civilization. In view of the accumulation of scientific data and the number of active research workers in all advanced countries, what can our association and its members do to be of the greatest service? As stated by our constitution, the objects of the association are "to promote intercourse among those who are cultivating science in different parts of America, to cooperate with other scientific societies and institutions, to give a stronger and more general impulse and more

systematic direction to scientific research, and to procure for the labors of scientific men increased facilities and a wider usefulness." Our membership already includes trained and amateur scientists, educators and intelligent laymen, about 13,000 of them, and it is increasing with the years more rapidly in proportion than is the population of the United States.

For three fourths of a century the members of the association have contributed individually and in groups to the advancement of many branches of science, and some of them have more or less successfully undertaken to interpret to the average intelligent person the story of nature so far as it has been made known by scientific research. All these activities have been helpful, and valuable service has been rendered by the association as a whole, especially by bringing together large groups for the consideration and discussion of the scientific problems of the day.

The title of the association implies association for a definite purpose, "the advancement of science." This in our modern life means also the physical, mental and moral advancement of the human race, not only our immediate associates and fellow Americans, but every human being on the earth's surface, and, for that matter, every form of life that is not predatory or inimical to the welfare of humanity. Is the association now doing its part in the formation of public opinion and in the guidance of social movements; is it in touch with the layman, or is it a professional organization that is slipping away from its great opportunity of informing and arousing the interest and enthusiasm of the American people and the intelligent people of all countries? These questions are important, for to-day a story of science clearly and simply told is welcomed by the press, the author of textbooks, the lecturer, the encyclopedist and agencies for the dissemination of information in all nations.

The association should act as a liaison agency between professional science and the public. It also should act as the liaison agency between the various sciences. The greater the specialization the greater the need of cooperation. In the advance of science, siege tactics have taken the place of guerilla warfare of former days. The big industrial establishments like the Western Electric Company, the General Motors Research Corporation, the General Electric Laboratories and many others show how much more can be accomplished by the combined efforts of experts in various fields of science. This must be carried much farther than an occasional symposium or joint meeting between different departments of the association. The important problems of the day require the cooperation of men from various sciences. For instance, to make an inventory of future energy supplies of the world would require cooperative study by geologists, chemists, physicists, engineers, biologists and sociologists.

More attention must be paid to the unity of nature in order to counteract the artificial divisions which are the natural result of specialization in research. We need men and women who can tell the story of life as a whole, as a zoological story, and who can combine the parts and picture its evolution, character and broad relations, and this applies as well to all scientific, historical and social fields of research.

There is something wrong when ten minutes is the limit for presentation of a valuable paper, with practically no time available for discussion. A few papers, ably discussed, and *leave to print* for others would probably add more to the value and interest of the program than a multitude of papers hurriedly presented, with no opportunity for discussion. For the irreconcilable specialist, the special society or the local general society is open. Again, the poorly prepared paper and even the masterpiece ineffectively delivered is an almost criminal action when we consider the time and effort involved in getting a large group into one place to hear and consider it. Such a loss of time and energy should not be imposed on professional men or laymen. A method should be devised to correct it. Modern life has developed great traffic and social problems that will ultimately be solved, and the association will solve its problems if a group of vigorous, clear-thinking, trained members take them up. I say members, as I think the segregation of women scientists would be an injury to science and the association. Will you attack these problems or will you sit idly by and permit your opportunities to pass into other hands? This was done once and the great work of the National Research Council was initiated and developed by a trio of men who had vision, purpose and inflexible determination to be of service to their country and humanity.

Is the association doing all that it could in connection with the great problem of conservation? Do we realize that our future national progress and the progress of all peoples will be determined, not so much by the acquisition and appropriation of new resources, as by the degree to which we are able to perpetuate and more efficiently to utilize those we already have. Such progress is absolutely dependent upon scientific research and education; it would be difficult to name a single branch of science that is not concerned. The research workers and educators who are members of this association can render no greater service than by concentrating an increasing amount of their effort on the multitudinous phases of this problem.

The United States' unprecedented growth and her present commanding economic position have been made possible by abundance of natural resources. In-

dividual and public economic policies have been predicated on this abundance. Minerals, forests, fur and game animals, agricultural soils, range lands, fish, and water resources were all seemingly inexhaustible in supply, and all have been appropriated and exploited recklessly and wastefully. The cream has been skimmed, and, all too often, the milk has been thrown away.

The whole philosophy of exploitation has been based on the theory of making maximum profits for the exploiter, rather than the ideal of greatest service and lasting benefit to the people of the world as a whole. The resources seemed unlimited, and it was assumed that future requirements would adjust themselves automatically and that posterity would take care of itself.

Now the point has been reached where it is evident that the resources have a limit. Expansion can not continue indefinitely, nor can even the present scale of consumption be maintained as population increases, unless steps are taken to replenish the supply. The pressure of scarcity and increasing costs of exploitation demand the elimination of wastes, the intensive utilization of the resources that are left, and the discovery or creation of new supplies.

A large percentage of our good agricultural soils have been appropriated, and the further expansion of crop production to feed our growing population must come largely through utilization of the poorer land or through more intensive cultivation and fertilization of existing farms. Even more is this true of our pasture and range lands, the *per capita* area of which has been reduced by almost one half since 1890.

Using almost as much timber as all the rest of the world combined, the United States passed the highest point of *per capita* consumption nearly 20 years ago. Even now four times as much is consumed as is grown each year, and only one fifth of the forest land is set apart definitely for timber production. In spite of the growing shortage of timber and the mounting costs of bringing it from remote regions, scores of millions of acres of once productive forest land are lying idle, and we are still wasting two thirds of all the wood that is cut.

The story of our wild life and our waters is little different. Birds, fish, shell-fish, fur bearers, game animals, all have reached an alarming stage of depletion as a result of destructive exploitation. Streams, lakes and coastal waters have been polluted. Many of the streams and lakes which could afford a perpetual source of food, power, irrigation water, recreation, water for drinking, sanitation and other domestic uses, as well as channels for cheap transportation, have been reduced in flow or filled with sediment, following forest destruction or unwise cultivation or pasturing on their watersheds.

All of these are renewable resources. With wise use none of them need have been depleted, and most of them can be made even more productive than they have been in the past. Few would go so far as to contend that such replenishment is unnecessary or undesirable. Many, however, consider it impossible, and even assert that major reductions of the waste in utilizing existing resources are impracticable. The reasons are said to be economic: more intensive farming will not pay, reforestation is too slow and costly, there are no profits in utilizing waste materials.

Yet economic impracticability is frequently only a longer name for ignorance. The discovery of new principles or new methods may make it economically practicable to intensify farming. Better understanding of silvicultural principles and closer study of the life history of our forests will show us how to utilize that resource without jeopardizing its continued productivity, and without increasing the economic burden on the users. Thorough technical knowledge of the product, whether farm crops, timber or what not, will enable us to utilize profitably a great deal that is now wasted.

Our mineral resources, as a general proposition, can not be renewed through human effort, at least in the present state of knowledge. But even with them, the available supplies can be extended almost indefinitely through the discovery of new methods of extraction, or through the discovery and utilization of substitute materials.

To obtain the results desired it is evident that the great masses of humanity have yet to be educated in the scientific method of thought and action, not only in darkest Africa, but here in the United States and in all countries. This is the greatest task immediately before us. All scientific men and women may do their bit—*first,* by training themselves to observe accurately, to think straight and then to record clearly and honestly, and to draw warranted conclusions based on the facts presented, "free from previous preconception and prejudice"; *second,* by reviewing the mass of technical information with which they are familiar and telling the story they have learned in simple, clear language, free from obscure, complicated, technical and verbose wording. These simple suggestions apply not only to research workers in science, but to all the professional classes as well, theologians, doctors, lawyers, statesmen—especially lawyers and politicians, and of course professional teachers in schools and colleges.

That the scientist should have the virtues of charity, tolerance, broad-mindedness, patience, persistence and a very high regard for his fellow man is absolutely essential if he is to reach the heights and be of the greatest service. Agassiz and Pasteur were great scientists and great souls, and gave service by teaching as well as by their example of living on a high plane of thought and action. Some other men have

been brilliant contributors to knowledge, although their general manner of living may have been an injury rather than a service to mankind. We need to be grateful for the constructive service of each life, and our criticism of those who have passed and of those who are still active needs to have a broad friendliness as its basis. I believe, too, that a good scientist should be a good Christian, and a good Christian should be a good scientist in his method and work, as both are seeking the truth and the fundamental principles underlying their respective fields of endeavor.

Besides the necessity for each individual to train and conquer himself and to exercise such influence as may be possible on those within his immediate environment, there is great need for him to engage in cooperative public work, by associating with others of similar aspirations, and bringing legitimate influence to bear on all agencies that are concerned in any way with the educational system of the people, from the kindergarten to the university, from the leaflet of the advertising promoter to the great newspapers, magazines and books that make up the thousand and one publications of our day. His influence must also be brought to bear upon the important visual agencies of the motion-picture screen and every other form of illustration, as well as on all those agencies that are seeking to develop "the co[illegible]ciences, the ideals and the aspirations of mankind." The scientific method must be applied to all these factors if we have faith in its ideals.

Is it not practicable for the association to organize a progressive, live committee of men and women to deal with the popularizing of scientific knowledge? It might arrange special sessions for the public to which the layman could go with the feeling that they were for his entertainment and his instruction and not solely to arouse the interest of specialists in their particular field of research. Of all human beings, the child is the greatest and most active investigator of all that pertains to his environment. Why not provide for a junior section of the American Association, and last and in some respects the most important, a woman's section and sessions, at which all the scientific problems of peculiar interest to woman could be considered? We have a strong nucleus of women members, but they should be one of the great influences within the association for developing and carrying forward its work. Then there is the much discussed business man, who has a more or less hazy conception of science and scientific method, depending on whether he considers it affects his interest for good or evil. He would be a better business man, a better citizen and more successful in all his relations in life if he had a working knowledge of scientific method and principles at his command.

Every member of our association should work individually and collectively according to his or her opportunity and ability in supporting the scientific method and in insisting that, in all education of every kind and degree and for all classes, the purpose is to develop without prejudice or preconception of any kind a knowledge of the facts, the laws and the processes of nature in all natural and human relations. The natural weakness and incompleteness of all things of human origin will frequently baffle, mislead and confuse, and may even apparently bring temporary defeat, but in the long run there is no other way to eradicate sciosophy, advance the physical, mental and moral welfare of the race and justify our existence and opportunities for service as sentient human beings.

The Pilgrim fathers knew little of science, but they brought the great principles of law, truth, freedom and faith in God to America. Are we doing all in our power to perpetuate and develop them in connection with the multiplex activities of the world of to-day?

CHARLES D. WALCOTT
SMITHSONIAN INSTITUTION

THE FOUNDATIONS OF THE THEORY OF ALGEBRAIC NUMBERS[1]

ONE approaches with considerable hesitation a task in which on the one hand he is to give to the general reader some notion of an abstract scientific subject, while on the other hand he is to write something worth reading by the specialist in this subject. The task before me is to write something that is fit reading for the non-mathematician which is fit for the mathematician to read. My thesis has to do with the foundations of a theory which is of much interest to scientists and to mathematicians. I shall try to present it in such a way that one may foresee the methods that are adopted in the development and extension of this particular mathematical subject and may observe the generalizations that as a rule are applicable to mathematical theories. I shall attempt further to show that the truths established in mathematics must be used to standardize the truths, if such exist, of the general laws and principles that are derived for other sciences, and, in a measure, for all branches of human knowledge. Emphasis is also made of the importance of the universality of the truths that are found in the study of mathematics. A simple example

[1] Address of the vice-president and chairman of Section A—Mathematics, American Association for the Advancement of Science, Washington, December 31, 1924.

will illustrate. It is said that Newton on seeing an apple fall to the ground discovered thereby the law of gravitation. This law, which is applicable to all bodies on the earth, was held by Newton, through a process of observation and induction, to be true for all the heavenly bodies; that is, he held that the same laws which are true for the apple are true for the earth, the system of planets and the fixed stars, however distant. We shall see later that the entire theory must be modified. And it will be seen that in the testing of the accuracy and generality of the Newtonian laws recourse must be had to the very theory that I propose to outline in the present paper.

It may be observed that twenty-five years ago we were led to believe that certain theories of physics were firmly established upon accurate and sure bases; that advances were to be made upon the firm structure already established; and that further developments for the most part were to be had only through experimentation with elaborate and costly apparatus. Since then the entire structure of the science has been greatly altered; many marked and revolutionary changes have been made; the older text-books have been discarded. And this is what has been experienced in the oldest and most accurate of the experimental sciences!

With such unstable conditions in the sciences in which the theories and laws are created through experimentation, observation and induction, and with our ever-changing philosophies which underlie the very roots of civilization, where, may we ask, are we to seek the truth and, in fact, what is the truth? It is fortunate that our mathematical theories offer an immediate answer in that the experimental sciences and the basic philosophical theories may be accepted as fixedly established and may be gauged as accurate in so far as they have definite mathematical bases or conform with those logical principles which are essentially mathematical. It is, therefore, of the utmost importance in any branch of mathematics to establish for it universal truths, truths that however generalized remain invariable.

It is worthy of note that the mathematical theories in their generality have usually preceded the other sciences; in many cases the practical sciences have suggested fundamental mathematical principles. These principles, in turn, when developed have become important branches of mathematics, the advances usually being much more rapid than in the experimental sciences. Thus the practical value of a mathematical theory may not become evident until long after the theory has been developed. There are many branches of mathematics which, seemingly evolved solely for their own sake and apparently as abstract exercises for mathematicians, have eventually been of the utmost practical value. It follows that we can not consider mathematics apart from their utilitarian value, or along with it, but rather we must consider the overlapping of the two. In a great measure, it is due to the fact that abstract mathematics is a thing in itself that its progress has been so rapid. The above remarks are illustrated in the subject of this paper, namely, *the theory of algebraic numbers*, or, *general arithmetic*, the meaning of which becomes manifest as the discussion proceeds.

It has been said that "arithmetic stands alone in the simplicity of its fundamental postulates, the accuracy of its concepts, the purity of its truths." *General arithmetic* has burst from the bonds in which of old it was confined. The ancients would restrict it within the confines of geometry. The theory is a modern creation. However, it wants in nothing that made the older arithmetic attractive. Starting with the conception of the absolute whole number, the domain of arithmetic has been enlarged step by step. These advances, like most other advances that have had to do with the extension of human knowledge, have always been attended with slowness, doubt, misgivings and adverse criticism. It is seen that fractional numbers were added to integers; negative numbers to positive numbers; imaginary numbers to real numbers. The early algebraist called the negative roots of an equation *false* roots. There are numerous problems where the quantities sought from an equation do not admit *opposites;* and there are innumerable cases where only positive whole numbers have a meaning, fractional quantities having no significance. However, this should not, as it did, argue such quantities into the background, when it comes to the complete solution of the algebraic equations. For, on the other hand, the reality of fractional or negative numbers is sufficiently warranted in that in innumerable cases they find adequate justification.

Similarly, the imaginary quantities were accepted with much hesitation and mistrust. The metaphysics of these positive and negative real integers, as well as of the positive and negative complex numbers, is susceptible of visualization if concepts of a geometrical nature were desired. The absolute or positive integers may be represented by a series of points that are situated on a straight line at equal (which we call *unit*) distances apart. A fixed point is taken as the origin and marked zero, the next point on the line being 1, the point after this being 2, etc., the line extending in this (positive) direction indefinitely. For a presentation of the negative numbers, it is only necessary to extend the line on the opposite side of the origin, the unit negative distances being marked on it beginning with the origin.

To visualize the complex integers suppose the above

line lies in a plane that is unlimited in every direction. Parallel with this line and at unit distances apart, draw other lines. Then through the origin draw a line perpendicular to this system of lines. The points of intersection on the one side of the original line with the system of lines just indicated may be denoted by 1i, 2i, 3i, . . . , while those in the opposite direction (on the other side) of the original line, may be called $-1i$, $-2i$, . . . Parallel to this latter line, draw a system of lines that are everywhere unit distances apart. This system of parallel lines makes with the first system a distribution of the entire plane into small squares. The vertices of these small squares correspond to complex integers. Observe, however, that the second system of lines has on the plane as much of an objective reality as has the first system. And, in fact, in the plane these so-called imaginary points (or quantities) have as *real* a significance as do the real points, positive and negative, on the line first drawn. Thus it is seen that to the points of intersection of these two systems of parallel lines there correspond complex integers and *vice versa;* and, observe that the points on the line first drawn, that is, the real integers, are included in the general class of complex integers.

The question now is: Do these complex integers obey the same laws and rules that have been established for the real integers? In particular, if a complex integer be resolved into factors, which can not be further resolved into factors, is the final result unique? And that is, can the distribution of a complex integer, as is the case of a real integer, into its prime factors be effected in only one way, if the order in which the prime factors are arranged is neglected? To all these questions there is an affirmative answer. Note, however, that we have no right to assume *a priori* that the theorems true for a restricted class of integers which lie on a line are also true of the more comprehensive class of integers which as above defined lie on a plane.

Although the bounds of the ancient geometricians do not allow us to go much further, we shall not stop with the introduction of the so-called complex numbers. Instead, we shall extend the limits of our investigation by the introduction of more general types of integers and numbers and, correspondingly, we shall introduce more extended geometries. Those who had to do with the introduction of these so-called *algebraic numbers* and who solved the questions just raised were the ones who established the theory with which we are concerned. Gauss, a mathematical scientist, algebraist and arithmetician of very great ability, extolled Fermat, Euler, Lagrange and Legendre as men of "matchless honor in that they had opened the way to the sanctuary of this divine science (theory of numbers) and had revealed how great were the treasures with which it was enriched." These men, who were the forerunners of the particular kind of numbers (algebraic) that are treated here, are next introduced.

Cajori, in his valuable "History of Mathematics," tells us that Diophantus, who flourished about 250 A. D., at Alexandria, completely divorced algebra from the methods of geometry. Equations which admit as solutions positive numbers when there are more variables than equations, are known as *Diophantine* equations. The celebrated cattle problem of Archimedes (stated in Cajori's history), and which antedates this period about five hundred years, is a typical example. Simpler examples are introduced here illustrative of problems whose answers are necessarily positive integers:

Problem 1°: A farmer wished to stock his farm with exactly one hundred animals. He paid 50 cents a head for pigs, three dollars for each sheep and ten dollars apiece for cows. He spent exactly one hundred dollars. How many of each did he buy?

Problem 2°: A lady told the postmaster to give her exactly one dollar's worth of stamps and in such a way that there are as many one cent stamps as two cent stamps and the remainder only in three cent stamps. How long did she wait for the stamps?

Problem 3°: A certain Egyptian queen, meeting her three suitors, gave from her basket one half of the cherries and one over to one of the suitors, one half of the remainder and one over to the second, and one half of what was left to the third suitor. She then agreed to accept that suitor who could first tell her how many cherries there were in the basket.

The answers to this problem are 14, 22, 30, 38, 46, . . . The second problem admits no answer and the first problem has one answer.

Fermat (1601–1665), a lawyer and mathematician of exceptional ability, interested himself in restoring and translating into Latin certain books and fragments that had been handed down from the ancient mathematicians, in particular, those of Apollonius of Perga and of Diophantus. Parenthetically it may be observed, if one will read Fermat's "Oeuvres" (Tannery Edition) III, p. 121, and then the works of Isaac Barrow (1630–1677), who was versed in Fermat's works, that Barrow's pupil, Isaac Newton, did not have far to go in the discovery of the differential calculus.

In his "Observations sur Diophantus," *loc. cit.*, p. 241, commenting upon the solution of the equation $x^2 + y^2 = z^2$, which was first completely solved by Diophantus, Fermat writes:

Au contraire, il est impossible de partager soit un

cube en deux cubes, soit un bicarré en deux bicarrés, soit en général une puissance quelconque supérieure au carré en deux puissances de même degré; j'en ai découvert une démonstration véritablement merveilleuse que cette marge est trop étroite pour contenir.

The proof of the impossibility of the solution of the equation $x^n + y^n = z^n$, $(n > 2)$ in integers, is the celebrated Fermat greater theorem. A large number of problems of a similar nature due to Fermat are found among others in the "L'Inventum Novum" (published in Fermat's works) of Father Jacques de Billy, who, together with his intimate friend, Claude-Jasper Bachet, as well as Euler (1707–1783) and Lagrange (1736–1813), interested themselves particularly with the solutions of Diophantine equations. Such problems led at once to the study of the theory of indeterminate equations, congruences, etc. In particular, Legendre (1752–1833) gave a proof of the so-called law of quadratic reciprocity (see Crelle's *Journal,* Bd. 30, p. 217).

Gauss (1777–1855), in the thirtieth section of his "Theoria Residuorum Biquadraticorum," writes:

> The theorems relative to the biquadratic residues are not shown in their greatest simplicity and in their genuine beauty until the field of arithmetic (Campus Arithmeticae) is extended to imaginary quantities and in such a way that numbers of the form $a + ib$ (i denoting $\sqrt{V-1}$, while a and b denote indefinitely all real integers from $+\infty$ to $-\infty$) constitute without restriction the object of this field. These numbers we shall call complex integers and in a manner that the real integers are not opposed to the imaginary but are to be regarded as constituting a class of integers among the imaginary integers.

It must not be assumed for a moment that Gauss was the first to introduce imaginary quantities into analysis. Lagrange, for example, seemed as familiar with them as we are to-day.

Abel (1802–1829) (see his Works (Lie edition) II, p. 219), writes: "What do we understand by the algebraic solution of an algebraic equation." This question he answers as follows:

> In general there are two different cases according as the coefficients will be *rational functions* of a certain number of quantities x, z, z′, z″, . . . which will contain at least one independent variable. . . . In the second case where we consider the coefficients as constant quantities, we may regard the coefficients formed from other constant quantities by the aid of rational operations.

In other words, when we consider algebraic equations, their coefficients belong to certain fixed fields, domains or *realms of rationality* in which are allowable the rational operations of arithmetic. And, if any new quantity whatever is added or adjoined to this domain, the quantities in the resulting new domain consist of all rational combinations of this new quantity together with the quantities that at first constituted the domain. Our calculation, computation or process of reasoning which has to do with the solution of the algebraic equations has to be done with reference to a domain regarded as fixed in the premises, which domain we shall call a *stock-realm.* As we ourselves are rational when we think, and as this process of thinking is carried on with reference to a domain in which the admissible operations have already been designated as rational, I prefer to designate such domains as *realms of rationality,* a terminology which was adopted by Kronecker (1823–1891). For example, if to the natural realm, in which all the usual computations are made, we adjoin the quantity i, we have a realm consisting of all the complex numbers (fractional and integral) as defined above. If further we adjoin a quantity u, we obtain a realm consisting of all rational functions of u whose coefficients are complex quantities. This process may be continued indefinitely. We may thus form realms that are extended without limit.

With Abel (Works I, p. 479), we may say that a function $\varphi(x)$ whose coefficients are rational functions of a certain number of known quantities a, b, c, . . . is called *irreducible,* when it is impossible to express any of its roots through an equation of lower degree whose coefficients are likewise rational functions of a, b, c, . . . However, by adding (adjoining) other quantities to the fixed realm, the given function may well be factorable in the extended realm. And this notion is the one given and employed by Galois (1811–1832).

In the natural realm, *i.e.,* the realm of numbers usually called rational, an integer, say 6, satisfies an equation $x - 6 = 0$. The quantity i satisfies the equation $x^2 + 1 = 0$. In general an algebraic number satisfies an equation of the form $a_\sigma x^n + a_1 x^{n-1} + \ldots + a_{n-1} + a_n = 0$, where the a's are quantities that belong to a fixed realm. If $a_\sigma = 1$, and the other a's are integral, these algebraic numbers are called algebraic integers; and if further, $a_n = 1$, these algebraic integers are called algebraic units. These units play a rôle analogous to the one of ± 1 in the usual realm.

If to the natural realm any number of algebraic quantities be adjoined, the resulting realm is called an *algebraic* realm; and any quantity of this realm, and that is, any rational combination of the numbers that have been adjoined together with the original numbers of the realm, is itself an algebraic number and satisfies an algebraic equation. It may be

proved that any algebraic number multiplied by a suitable rational integer is an algebraic integer in the sense defined above. These integers associated with their respective realms are the subject of our present inquiry.

The theory of algebraic numbers and the Galois theory of equations have their common origin in the general theory of algebraic realms, so that these realms constitute an essential rôle in questions of algebra and analysis. In fact the focus of the modern theory of numbers is the theory of the algebraic realms from which radiate its relations with algebra, functions, geometry and analysis. It is seen that the definitions of Dedekind, the arithmetical concepts of Weierstrass and Cantor's general notion of number lead to an arithmetizing of the function theory which finds exposition in the principle that a theorem may be regarded as proved only when in the final analysis it may be reduced to the relations which exist for rational integers. This notion was carried to the extreme by Kronecker, who often declared, "Die ganze Zahl schuf der liebe Gott; alles Uebrige ist Menschen Werk." By the introduction of number into geometry, the modern non-Euclidean geometry may be developed from a purely logical basis; while the so-called geometry of numbers (Minkowski) serves to illustrate and oft-time to derive very simply general arithmetical theorems by means of concepts considered geometrical.

In the advancement of science there is a certain continuity. New methods are employed in the solution of old problems; and when the older problems are the better understood and further developed, new problems of themselves are proposed, and so on indefinitely. In mathematics a simple example will illustrate: The Riemann surface offered a means of studying many-valued functions in $z = x + iy$. Through these surfaces a new kind of geometry was revealed for the inversion of Abelian integrals; the hyper-geometric series could be regarded from a different viewpoint; automorphic functions came into being; while the elliptic modular functions took on a new interest.

The geometry of Euclid has been more or less restricted in that certain axioms must have their being. Do away with the one that pertains to parallel lines and we are in a more general geometry, which of course includes the Euclidean geometry. This new geometry may be regarded as a particular kind of number triply extended in which the square of an element of arc is expressed through a quadratic form of the elements of the coordinates. Further, it is possible to introduce, instead of a triple multiplicity, a quadruple multiplicity by the introduction of a fourth variable t in a space-time geometry about a space-time origin $x = 0 = z = t$. And this more general geometry includes the two just mentioned. In this extended geometric realm we have among other things to investigate what are the analogues of the Newtonian mechanics and other phenomena included in the usual physics. The notions of continuity, maxima and minima, extremals, etc., are first of all to be considered and definitely fixed. These extended geometric realms may well be called "bodies" (Körper). Thus we have a geometric realm, a "body," in which geometric, physical, electrophysical phenomena have their being and as such are to be studied just as in the number theory exist extended realms in which generalized number is to be studied. This latter is the problem before us, a problem which in a more or less degree has been solved. Thus, as we said in the beginning, mathematics must blaze the way through the forest of uncertainty and let the physical sciences follow the trail.

It would take us too far afield to introduce here the so-called "Welt-postulat" of Minkowski. This was founded upon three very simple assumptions due to which the motion of a material point is made to depend upon a system of four differential equations. These reduce to the three Newtonian equations when the velocity of light is made indefinitely large, or when for the time t the local time (Eigenzeit) τ of the material point is substituted, the fourth equation in this case offering an expression for the law of conservation of energy; or inversely, if we start with the postulate of relativity in the development of mechanics, the equations of motion follow at once from the energy theorem. The Newtonian theory of gravitation must be modified to satisfy this "Welt-postulat" and in the doing of it the Newtonian mechanics are made to harmonize with the more modern electrodynamic theory. It would thus appear that the real meanings of the laws of nature are to be properly understood when the elements that constitute the generalized domains (Körper) are correctly interpreted, and when the laws which the quantities in these realms must obey are definitely determined and fixed.

Legendre's quadratic law of reciprocity was mentioned above and it was seen that the theorems relative to this theory were best understood when the usual realm of arithmetic is widened by the adjunction of the quantity i, the realm thus becoming R (i). So also the meaning of the cubic law of reciprocity is revealed in its clearness when the well-known quantity ω is adjoined to the usual realm of arithmetic. In these two extended realms R(i) and R(ω) there exist no essentially different principles from those of

the usual arithmetic. For example, by definition the number $a + bi$ is integral when a and b are rational integers. Observe that this number satisfies the equation $x^2 - 2ax + a^2 + b^2 = 0$, where the coefficient of x^2 is unity and the other coefficients are rational integers. The sum, difference and product of any two such integers is an integer. If further α, β, γ are any three such integers and if $\alpha = \beta\ \gamma$, we may say that α is divisible by β or by γ; β is a divisor of α, so also is γ. Further, every complex integer is factorable into prime factors in only *one* way. A complex integer $a + bi$ may be taken as a modulus of linear, quadratic and higher congruences with associated theorems that are analogous to those for real integers and moduli. Corresponding to every integer $\alpha = a + ib$ there exists a system of $a^2 + b^2$ integers such that no two are congruent (mod α), whereas every integer of R(i) is congruent to one of these integers (mod α). Euclid's method of finding the greatest common divisor is also applicable. The so-called Fermat Lesser Theorem and the Wilson Theorem may be applied to all these integers, and there exist the analogous theorems of primitive roots and the analogous laws of quadratic and cubic reciprocity. The principles just enunciated constitute what is known as the *Arithmetic* of these realms. For the more general realms there exist additional theories, particularly one which treats of the numbers of classes into which the units of a realm may be distributed and another which has to do with the determination of the number of fundamental units which are found in a given realm. These two theories of Dirichlet are discussed at greater length later.

(*To be concluded*)

HARRIS HANCOCK

UNIVERSITY OF CINCINNATI

THE ECLIPSE OF JANUARY 24, 1925

THE eclipse of the sun taking place on January 24, 1925, is chiefly remarkable by the fact that the zone of totality passes over an area more thickly populated than any other of modern times. At sunrise somewhat west of Duluth the zone includes such cities as Toronto, Buffalo, Rochester, Hartford and New Haven, while close to the northern limit are Syracuse, Springfield, Providence and to the southern limit Wilkes-Barre and New York.

It seemed advisable to make use of this fact partly to secure an exact delimitation of this zone and partly to interest the people generally in the scientific and spectacular features of the phenomena. A special committee of the American Astronomical Society was therefore formed to take charge of the general publicity work required.

The most important factor was of course to secure the cooperation of the daily press. Articles giving details free from technical terms have been sent out through the usual distributing agencies to all newspapers whether published in the big cities or in the small country towns. Starting early in November, these or extracts from them were very generally printed and by the end of the month, public interest was becoming very evident.

Newspapers with large resources arranged for interviews and special feature "stories," while other articles were contributed by astronomers, professional and amateur, for the local press in the smaller cities. Articles in the magazines were left to the enterprise of their editors.

The delimitation of the northern and southern boundaries of the zone is being made by asking for answers from any one interested to certain questions framed in such a way that a person without a knowledge of astronomy or of eclipse phenomena can give information as to whether the eclipse was total or not at his position. Observations of the edge of the moon's shadow as it passes over the earth, of the visibility of the corona and of the sun itself are requested. Just within the zone, the time of duration of totality also furnishes a good position. In connection with this, professional astronomers have been asked to make as many observations of the moon during the month preceding and that following the eclipse, so as to secure a knowledge of its path during this period which shall have the highest possible accuracy. The main reason for this arises from the fact that only during a solar eclipse can an accurate position of the moon be obtained when it is close to the sun. This therefore furnishes positions through a lunation including one at new moon, which last at other times is missing.

The comparison of the different classes of observation, meridian, extra-meridian, photographic and by occultations will be a by-product of the campaign.

The eclipse is also unique in the fact that the zone of totality includes some ten or twelve observatories. These of course have their programs for observation, and other observatories are as usual sending expeditions into the zone. A general feature of most of their work will be the photography of the corona. The time of the year, however, makes the weather problem doubtful, the best chance for clear skies being near the coast and that some fifty per cent. It may happen, however, that the sun will only be free from clouds in parts of the zone not occupied by the professional astronomer and here again the cooperation of the public is asked. Any photograph showing the corona sufficiently to indicate its type is better than none, whatever the scale. It is also suggested that

Petzval doublets and telescopic lenses should be used if they are available.

An extensive radio campaign is being organized by *The Scientific American*. This includes the effects on transmission of the darkness by pairs of observers placed north and south of the zone, one transmitting and the other receiving, the change of intensity being recorded by the receiver of words in selected paragraphs spoken by the transmitter. Another feature with the same idea in mind and reaching all those who have receivers is the broadcasting through certain selected stations of copy selected in advance, the receiver noting the words which show a change of intensity. The committee is also indebted to the editor, Dr. E. E. Free, for much assistance through the journal and its staff in its general publicity campaign.

The committee wishes to take the opportunity to ask all those who have facilities for instructing the public in their neighborhood concerning the eclipse to make full use of them.

Teachers in schools can give talks to the children while lectures to small and large groups both of children and adults, stimulation in various ways through the local press, will all be of assistance. More particularly persons accustomed to making observations of any natural phenomena can assist by instructing those with whom they come in contact how to make the observations asked and to answer the questions. In particular, surveyors and all those familiar with the use of maps can be of very valuable assistance by showing how to give or plot the observer's position. They can assist in the same way by furnishing the local press with detailed maps of their localities, the inch to the mile map being in general sufficient when the position is carefully marked.

The general and scientific literature relating to eclipses is summarized in Professor S. A. Mitchell's "Eclipses of the Sun." An excellent account for the general reader in a small compass is found in the "Handbook of Eclipses" by Mrs. I. M. Lewis. A brief account of the phenomena and arrangements made for general observation by Professor H. N. Russell and the writer will be found in the January number of *The Scientific American*, where are also given the plans for the radio campaign. Any one accustomed to the reading of general scientific literature should have no difficulty in obtaining such material as he or she may need from these sources. The technical details with maps have been published in a pamphlet issued by the Nautical Almanac office and obtainable from the Government Printer, Washington, by sending 30 cents.

The following is the list of questions being circulated:

1. If the sun is not quite eclipsed at your station there will always be a bright edge of the sun visible, or perhaps only a single point. One bright point may appear on one edge of the sun before the other has entirely disappeared. At your station was there any time at which no bright edge of the sun was visible? Answer YES or NO .....

2. If the bright edge of the sun entirely disappeared, how many seconds elapsed before another bright part of the sun became visible? Answer ..... seconds.

3. Was the time set down in the last question merely guessed at or was it actually measured? If measured, how was the measurement made? .....

.....

4. The fringe of light surrounding the sun and called the corona is fully visible only if the face of the sun is entirely covered. At your station was there any time at which you could see the corona all around the sun? Answer YES or NO .....

5. Could you see any stars or planets at the time when the sun was most completely covered and how many did you see? .....

(If convenient draw a little map showing the positions in the sky of the eclipsed sun and of the stars and planets that you saw.)

6. If you are on a high building or a hill near the edge of the shadow path you may be able to see the shadow advancing across the country. If so, what buildings or other land-marks were inside and what were outside the edge of the shadow? .....

Landmarks inside the shadow: .....

Landmarks outside the shadow: .....

7. It is necessary to locate your position very accurately, so that the engineers who compile the reports will know just where to place your observations on the map. Accordingly, give your position by means of the nearest street intersection (if in a city or town) or by means of some easily located building such as a railroad station, a town hall, or some landmark which can be placed easily on a map by a person familiar with the district

.....

If you have a map of your district published in a newspaper or from any other source, mark a cross on the map at the position where you stood and send in the map with your report.

Even if only one of the questions 1 to 5 be answered, question 7 should be carefully answered.

Name .....

Address .....

Answers may be sent to "Eclipse," National Research Council, or the Editor, *Scientific American*, 233 Broadway, New York City.

It is hoped that a coupon with the above questions may be published by the newspapers in the days just preceding the eclipse, and all who have opportunity to secure its insertion are asked to see that it is correctly printed. The efficiency of a local campaign will be roughly measured by the number and nature of the answers received from the locality in comparison with the density of the population. An in-

teresting by-product may possibly be a study of these answers from the point of view of the psychologist.

The arrangements for the general public to see the eclipse are mainly based on the idea of general cooperation. During the period of totality, all external lights, particularly those in the streets and from automobiles, should be extinguished. In order to achieve this result and to avoid accidents it is hoped that all street traffic may stop within a minute after a signal given by bells, factory whistles or similar means some two or three minutes before totality. Here again cooperation from the readers of SCIENCE in helping to organize this by information and advice to the executives of their localities will be helpful. The position that this is done for the general benefit of the public should be stressed.

For those living near but outside the zone of totality, the usual means of transportation to within the zone by automobile, trolley or train will be available. Special services are being arranged in some cases and it is hoped that there may be similar opportunities offered to the general public by the transportation companies. It is generally advisable to invite the public *not* to come to observatory grounds at the time of the eclipse, silence and freedom from external disturbance of any kind being necessary for the observers to carry out their programs properly. Assistance for this may in some cases be secured by surrounding the grounds by students, boy scouts or members of similar organizations with, perhaps, the assistance of the public guardians of the peace.

It is suggested that in the limits of the zone of totality, such organizations may be utilized to define the limit by placing individuals fifty yards or so apart along a road which has a general north-south direction. As the possible error of the predicted line may be a mile either way, the line should extend to this distance on either side of the predicted limit, which may be obtained from the map published by the National Almanac Office referred to above. Exact positions of the predicted limits given in latitude and longitude have been computed by the office and will be furnished if desired by the writer.

Astronomers attached to observatories will doubtless be glad to give such assistance as lies in their power in carrying out these objects. The American Association for Variable Star Observers, amateurs whose excellent work is now furnishing valuable additions to our knowledge of the stars, has already started to give its assistance both through its general organization and through its individual members. Their widely scattered membership ensures cooperation in many places not easily taken care of otherwise.

ERNEST W. BROWN

YALE UNIVERSITY

SCIENTIFIC EVENTS

OPENING OF THE RAMSAY MEMORIAL LABORATORY[1]

PRINCE ARTHUR of Connaught, who is president of the University College Equipment and Endowment Fund Committee, on November 12 opened the Ramsay Laboratory of Chemical Engineering at University College. The laboratory, which, as its name implies, is to serve as one of the memorials to Sir William Ramsay, is the first of its kind established at the college. It has been fitted up in buildings next to the School of Tropical Medicine in Gordon Street, and there is access to it from the college grounds. After experience has been gained there, the erection of new and permanent buildings is contemplated.

The opening ceremony took place in the botanical theater of the college. Sir Robert Robertson, chairman of the chemical engineering sub-committee, presided. He said that there was a want in this country of men with the technical training of chemists who were capable of transferring a laboratory operation to a large scale. Dealing with the details of training, he referred to a practice existing in the United States of taking students to works, and urged chemical manufacturers in this country to consider whether they could not afford similar facilities.

Prince Arthur of Connaught, in declaring the laboratory open, said that ceremony was the final act in the provision of a worthy memorial to that great man of science, Sir William Ramsay, who for twenty-six years, from 1887 to 1913, held the chair of general and inorganic chemistry at that college, and who by his remarkable series of discoveries during that period earned for himself a place in the first rank of the world's scientific workers and brought honor and renown to the college with which he was connected. After his death in 1916 a large circle of friends and colleagues, not only in this country, but in all parts of the world, decided that a fitting memorial should be raised in connection with his wonderful contribution to chemical science. The appeal was not only of a national character, but of an international character, and met with a ready response from all parts of the British Empire and the world. The memorial had taken two main forms: (1) The foundation of Ramsay Memorial Fellowships in Chemical Science, and (2) the foundation of a Ramsay Laboratory of Chemical Engineering.

The success of the first half of the scheme was shown by the fact that at present the fellowship trusts were administering sixteen scholarships held by carefully selected Fellows from Great Britain, Canada, Denmark, Holland, France, Greece, Italy, Japan, Nor-

[1] From the London *Times*.

way, Spain, Sweden and Switzerland. Professor E. C. Williams, of the Universities of Manchester and Leeds, was appointed a year ago to the Ramsay chair of chemical engineering, and it was under his guidance that the laboratories had been reconstructed and equipped. The beginning of work had not been actually deferred until that day, but for some time had been actively in progress. He was gratified to learn that, apart from the support given to the movement by the Ramsay Memorial Fund, which handed over a sum of £26,979, the Laboratory of Chemical Engineering had enlisted the ready and generous support of many of the great firms of this country which were connected with the chemical industry. A sum of approximately £1,390 a year for five years had been provided in this way. Even now further financial support was needed if the department was to be enabled to rise to its full possibilities as the handmaid of the chemical industry of this country.

RECOMMENDATIONS FOR FEDERAL ADMINISTRATIVE REFORM BY AMERICAN ENGINEERS

MORE than 50,000 professional engineers, representing thirty national and local engineering societies, have entered a movement for Federal administrative reform, according to an announcement made by the Engineering Council, New York.

The project will be discussed at a national forum to be held in connection with a meeting of the council at Washington, D. C., January 16 and 17.

Architects, contractors and representatives of other professions and industries are allied with the engineers in their attempt to bring about a reorganization of the Interior Department, called an archaic survival of the early days of the republic.

The president of the council, ex-Governor James Hartness, of Vermont, made public a resolution adopted by the council's administrative board instructing the committee on government reorganization as it relates to engineering matters "to adopt a policy of aggressively working for the complete project of the Department of Public Works as originally outlined in the McCormick bill and finally developed in the Brown plan."

Many millions of dollars can be saved annually to the nation's taxpayers and economy and efficiency promoted by coordinating the immense public works functions of the government, historically a prolific source of waste, according to Mr. Hartness, who made the following statement:

The American Engineering Council will aggressively endeavor to have included in the proposed division of public works all the construction work now done by the Government, which means, in the light of the present bill pending in Congress, that we shall endeavor to have included in that bill, by amendment or otherwise, work on rivers and harbors and by the Mississippi River Commission.

There will be a meeting of our committee on government reorganization as well as of the advisory council in Washington the evening of January 15 to develop concrete plans for carrying out the proposed changes.

Mr. Hartness also made public a second resolution referred to the administrative board which "deplored the failure of the committee on reorganization of government departments to recommend the transfer of rivers and harbors work from the Engineer Corps."

ROYAL INSTITUTION LECTURES

THE program before-Easter lecture arrangements at the Royal Institution of London has been issued. The subject of the Christmas course for young people is "Concerning the habits of insects," to be delivered by Mr. F. Balfour Browne, beginning on December 27, on "Insect collecting," followed by "The habits of bees and wasps" (December 30), "Caterpillars" (January 1), "The dragonfly" (January 3), "The water beetle" (January 6), and "The habits of insects and the work of man" (January 8).

The general course will begin on Tuesday afternoon, January 13, when Professor A. Fowler will give the first of two lectures on "The analysis of spectra"; on succeeding Tuesdays there will be two lectures by Dr. H. R. Hall on the "Prehistoric Greek and ancient Egyptian civilizations"; four by Professor Barcroft on "The color of the animal creation"; two by Professor E. N. da C. Andrade on "The evolution of the scientific instrument"; and two by Professor A. S. Eddington on "The internal constitution of the stars." On Thursday afternoons at the same hour, beginning on January 15, Mr. J. S. Huxley will give two lectures on "The courtship of animals and its biological bearings"; Sir William Bragg will deliver four on "The properties and structure of quartz"; Sir A. Smith Woodward two on "Dinosaurs"; Dr. Leonard Hill two on "The biological action of light"; and Mr. T. Thorne Baker two on "Chemical and physical effects of light."

The Saturday lectures will include four by Sir Ernest Rutherford on "Counting of the atoms"; and two by Professor J. H. Ashworth on a zoological subject to be announced later. The Friday evening meetings begin on January 16 with a discourse by Sir William Bragg on "The investigation of the properties of thin films by means of x-rays." Succeeding discourses will probably be given by Dr. A. W. Crossley, Professors J. W. Gregory, R. W. Chambers, T. H. Pear, Gilbert Murray, J. W. McBain, Principal Irvine, Mr. W. B. Hardy, Sir Ernest Rutherford, Sir Daniel Hall and others.

WORK IN FORESTRY

A COMMITTEE has been formed among foresters to bring about more uniform practices in studies of the growth and yield of forest trees. At the present time, there are a number of conflicting methods employed which make adequate comparisons of growth between trees of different regions impossible. It is the purpose of this committee to bring about more standard practices in the collection of field data and in methods of working up volume and yield tables. Three organizations which include the Society of American Foresters, the Association of State Foresters, and the U. S. Forest Service are represented on this committee. The members include M. B. Pratt and E. O. Siecke, state foresters of California and Texas; Professor T. S. Hansen, of the Cloquet Forest Experiment Station; Professor H. H. Chapman, of Yale University; Professor Donald Bruce, of the University of California; E. C. Behre, of the Northeastern Forest Experiment Station; D. T. Mason, of Portland; E. M. Munns, Forest Service, Washington, D. C., and J. S. Illick, Pennsylvania Forest Service.

S. T. Dana, director of the Northeastern Forest Experiment Station of Amherst, Mass., is making a study of the forest fires in the region served by the station. Some 4,000 records of fires in Massachusetts in 1924 have been analyzed, and the study contemplates relating the size, cause and spread of these fires to the weather conditions existing at the time the fires started. This is the beginning of the study, for records are available in New England and New York for ten or more years, and there are in all about 150,000 records of past fires on which to base the conclusions. Mr. Dana will have the help and assistance of the various state foresters in the compilation of this material.

T. T. Munger, director of the Pacific Northwest Forest Experiment Station, has just announced that the Secretary of Agriculture has approved the location of Portland as the headquarters of the station. Quarters have been secured in the Lewis Building, and arrangements are being made for the development of the work of the station during the next field season. The territory served by this, the newest of the forest experiment stations established by the Congress, includes Washington, Oregon, southern Idaho and southern Alaska. Its formation is the outgrowth of the work originally carried on at the Wind River station which is now absorbed into the larger one, though the work carried on at Carson, Washington, will be continued. The technical staff of the station includes, besides Mr. Munger, Leo A. Isaacs and R. E. McArdle.

SCIENTIFIC NOTES AND NEWS

DR. HORACE L. WELLS, emeritus professor of chemistry at Yale University and for forty years on the faculty of the Sheffield Scientific School, died on December 19, in his seventieth year.

PROFESSOR JAMES F. NORRIS, of the Massachusetts Institute of Technology, has been elected president of the American Chemical Society.

DR. MOSES GOMBERG, head of the department of organic chemistry at the University of Michigan, has been awarded the Willard Gibbs medal, which will be presented at the regular May meeting of the Chicago section of the American Chemical Society.

GEORGES CLAUDE, the inventor of a process for the production of synthetic ammonia, has been elected a member of the French Academy of Sciences, taking the place of the late B. Chardonnet.

THE Rivers Memorial Medal of the Royal Anthropological Institute for the year 1924 has been awarded to Dr. A. C. Haddon, professor of anthropology at the University of Cambridge. This is the first occasion on which the medal has been awarded.

SIR JAMES MACKENZIE, F.R.S., honorary physician to the King in Scotland, has been awarded by the University of Toronto the Charles Mickle Fellowship of that university. The fellowship is awarded annually to the member of the medical profession who is considered by the council to have done most during the preceding ten years to advance sound knowledge of a practical kind in medical art or science. Its annual value is about $1,500.

IN connection with the jubilee celebrations of the University of Leeds, England, the honorary degree of doctor of laws was conferred upon Sir Berkeley Moynihan, professor of surgery, and that of doctor of science upon Emeritus Professor Julius Berend Cohen, formerly professor of organic chemistry, and upon Emeritus Professor John E. Eddison, formerly professor of medicine, all of the University of Leeds.

DR. JOSE ARCE, rector of the University of Buenos Aires, was invested with an honorary degree by the University of Madrid, on his recent visit to Spain with the delegation from Argentina to attend the Spanish Medical Congress at Seville.

DR. WALLACE H. STROUD, for the past ten years chief chemist of the Wisconsin Department of Agriculture, has resigned in order to accept a position as secretary of the Soft Wheat Millers Association, with headquarters at Nashville, Tennessee.

DONALD H. CAMERON has resigned his position as instructor in physical chemistry at the State Univer-

sity of Iowa, to engage in research on crude oil emulsions for the Petroleum Dehydrating Company, Long Beach, California.

DR. ARTHUR C. PARKER, since 1906 State Archeologist of New York, has accepted the office of director of the Rochester City Museum.

DR. LESLEY H. SPOONER, formerly instructor in bacteriology at the Harvard Medical School, has been made medical director of the new Boston branch of the Life Extension Institute.

DR. A. PYPER, Pretoria, and Dr. Schneider, of Potchefstroom, South Africa, were awarded the Hamilton-Maynard prizes, on September 6, by the directors of the *Medical Journal of South Africa*.

DR. FRANK B. JEWETT, vice-president of the Western Electric Company, has been elected vice-president of the American Telephone & Telegraph Company and president of the Bell Telephone Laboratories, Inc., recently organized by the American Telephone & Telegraph Company, to take over the laboratory and research work formerly carried on by its affiliated concern the Western Electric Company.

DR. WILLIAM HENRY HOWELL, of Johns Hopkins University School of Hygiene, has been named a member of joint board of sanitary control to regulate health conditions in shops employing garment workers in Baltimore.

DR. FREDERIC S. LEE, research professor of physiology in Columbia University, has been appointed chairman of the campaign committee of the board of managers of the New York Botanical Garden.

DR. F. E. BROWN, of the department of chemistry at Iowa State University, was elected chairman of the physics and chemistry section of the Iowa State Teacher's Association at their state convention held in Des Moines, from November 6 to 8.

CHARLES G. DAWES, vice-president elect, has been elected a member of the board of trustees of the National Geographic Society.

PRESIDENT LEGUIA, of Peru, and Herbert Hoover, American Secretary of Commerce, have been elected honorary presidents of the Pan-American Scientific Congress.

AT the annual meeting of the New York Academy of Sciences on December 15, the following officers were elected for 1925: *President,* John Tatlock; *vice-presidents,* Chester A. Reeds, H. D. Senior, Carl P. Sherwin, Elsie Clews Parsons; *recording secretary,* Ralph W. Tower; *corresponding secretary,* Henry C. Crampton; *treasurer,* George H. Sherwood.

THE RIGHT HON. JAMES RAMSAY MACDONALD, M.P., and Lieutenant-Colonel Sir David Prain, late director of the Royal Botanic Gardens, Kew, have been elected trustees of the British Museum, to fill the vacancies caused by the deaths of Sir Archibald Geikie and the Right Hon. E. S. Montagu.

E. LEONARD GILL, assistant in the natural history department of the Royal Scottish Museum, has been appointed director of the South African Museum in succession to the late Dr. Louis Albert Péringuey.

DR. S. W. F. UNDERHILL, senior demonstrator of physiology at St. Bartholomew's Hospital, has accepted an appointment as research physiologist to the British Drug Houses, Ltd., and Messrs. Allen and Hanbury's, Ltd., in connection with the production of insulin.

DR. LORENZUTTI has been appointed director of the new antirabies institute recently organized at Trieste, similar to those at Padua, Bologna, Rome and elsewhere.

DR. R. E. TOTTENHAM, formerly assistant master of Rotunda Hospital, Dublin, who has been appointed to the chair of obstetrics at the medical school of the University of Hongkong, arrived in New York on December 15. Prior to sailing for the Orient he will make a study of medical institutions in the United States under the auspices of the Rockefeller Foundation.

DR. SAMUEL A. MITCHELL, director of the Leander McCormick Observatory of the University of Virginia, and chairman of the committee on eclipses of the American Astronomical Society, will make special observations of the total eclipse of the sun on January 24, at Wesleyan University, Middletown, Conn.

DR. FREDERICK F. RUSSELL, general director of the International Health Board, will sail for Europe on January 3, to visit public health institutions in Italy, France, Denmark and England.

DR. WILLIAM H. WESTON, JR., assistant professor of botany at Harvard University, has been granted leave of absence for the second half of the current academic year, to continue in Cuba some phases of the study and control of the sugar cane mosaic disease.

COMMANDER FRANK A. WORSLEY, who participated in an Antarctic expedition under Sir Ernest Shackleton, is planning an expedition to the South Pole, which will make its way northward over the pole from the Mackenzie Delta.

WILLIAM EINTHOVEN, professor of physiology, University of Leyden, gave a lecture under the auspices of the Herter Lecture Fund on "The relation of mechanical and electrical phenomena of muscular contraction with especial reference to cardiac muscle," on December 2, at the Johns Hopkins Hospital.

DR. CARL A. SCHENCK, of Darmstadt, Germany, founder of the Biltmore School of Forestry in Nova Scotia, gave a series of lectures at the New York State College of Forestry, Syracuse University, from December 17 to 19.

ON December 13, F. W. Peek, consulting engineer of the General Electric Company, Pittsfield, Mass., delivered an address to the Royal Canadian Institute, Toronto, on the subject "Lightning."

DR. EMERY R. HAYHURST, professor of hygiene and head of the department of public health, Ohio State University, delivered the De Lamar lecture at Johns Hopkins University School of Hygiene and Public Health, November 3, on "The occupational aspects of common disabilities."

R. NORRIS SHREVE, chairman of the dye division of the American Chemical Society, addressed the graduate students in chemical engineering at Columbia University, on December 18, speaking on the subject of the manufacture of beta-naphthol.

DR. CHRISTINE LADD-FRANKLIN lectured at Harvard University on November 7, on the connection between her theory of the color sensations and the work of König on the retinal valence-distribution curves. Her appendix to the English translation by Helmholtz, which goes over much the same ground, will appear in French in *L'Anné Psychologique*.

ON December 9, Dr. G. F. Loughlin, geologist in charge of the section of metalliferous deposits of the U. S. Geological Survey, addressed the members of the Geological Society of the University of Cincinnati on "The geology of Leadville, Colorado."

DR. ROBERT F. BRUNEL, head of the department of chemistry at Bryn Mawr College, died on December 24, aged forty-three years.

DR. OTTO R. EICHEL, of Albany, N. Y., director of vital statistics of the New York State Department of Health, died on December 24 in Geneva, while on leave for temporary service with the League of Nations, of which he was chief of the epidemiological intelligence and statistics section.

DR. FRANK N. WHITTIER, professor of hygiene and physical training at Bowdoin College and formerly professor of bacteriology and pathology, died on December 23, aged sixty-three years.

REAR ADMIRAL WILLIAM K. VAN REYPEN, formerly surgeon general of the United States Navy, died on December 22, aged eighty-four years.

JOSEPH TURNEY WOOD, a well-known British leather chemist, died on November 9.

THE United States Civil Service Commission announces an examination for an associate technologist (petroleum production) to fill a vacancy in the Bureau of Mines, Department of the Interior, for duty at Dallas, Texas, at an entrance salary of $3,000 a year. Receipt of applications will close on January 10.

THE committee on scientific research of the American Medical Association will receive applications for grants for aid to research on problems of importance to medicine. On February 15, 1925, action will be taken on the applications then on hand. Applications may be sent to the committee at 535 N. Dearborn Street, Chicago.

IT has been announced by Dr. William H. Welch, director of the School of Hygiene and Public Health of the Johns Hopkins University, and honorary president of the National Committee for Mental Hygiene, that the sum of about $30,000 had been given to that committee by the Rockefeller Foundation to establish scholarships in mental hygiene work.

THE late Anna S. Hall has left her estate to the Smithsonian Institution. She was the daughter of Charles F. Hall, the Arctic explorer who was never heard from after he went on his third expedition in 1879. Her estate, estimated at about $20,000, is what remains of the $25,000 awarded to her mother and other members of the family by the government.

THE Moore School of Electrical Engineering of the University of Pennsylvania has been presented with a complete laboratory equipment for the study of alternating current of the frequency used in telephony. The gift was made by the Bell Telephone Company of Pennsylvania, the American Telephone and Telegraph Company and the Western Electric Company. The apparatus is now being set up in a separate room of the engineering building, which has been designated as the high-frequency laboratory.

COLUMBIA UNIVERSITY has received from the dean of the school of chemistry of the University of France, two flasks and a U-tube used by Pasteur when he was dean of the Faculty of Sciences, University of Lille (1854–1857).

A FRIEND of plant physiology who desires to remain anonymous has provided a temporary endowment to aid the initial program of the newly organized American Society of Plant Pathologists. The principal is approximately $20,000, and the income therefrom is assured for three years, beginning July 1, 1925. The income is to be used in aid of any enterprises the society may sponsor.

ON December 3 the Viceroy of India laid the foundation-stone of the Technological Research Laboratory and opened the spinning-plant of the Indian Central Cotton Committee at Bombay. The laboratory will

undertake properly controlled spinning tests for the agricultural departments and will be able to interpret the results and arrange later for full-scale mill-trials before new cottons are brought into general cultivation.

THE introduction of the metric system in the Soviet Union, says the *Commercial and Industrial Gazette* of Moscow, is proceeding rapidly. By the beginning of July next year the Gosmeter will have completed the inauguration of the metric system in all branches of national industry, including the retail selling apparatus in the provinces of Moscow, Leningrad and Nizhni-Novgorod.

UNIVERSITY AND EDUCATIONAL NOTES

MEMBERS of the Board of Trustees of the University of Chicago have given the sum of $1,670,800 toward the $17,500,000 development fund which the university is seeking for the endowment of instruction and research and the erection of new buildings. It is also announced that Professor and Mrs. Frank R. Lillie have given to the university $60,000 for the erection of a building to be used for experimental zoology.

A GIFT of $7,500 has been made to the general fund of Union College, Schenectady, by Charles Coffin, former chairman of the board of the General Electric Company.

LAFAYETTE COLLEGE will receive the residue of the estate of David B. Simpson, of New York. The amount has not been made known.

DR. JOSHUA C. HUBBARD, of the Boston City Hospital, has been appointed professor of clinical surgery at the Harvard Medical School to fill the position made vacant by the resignation of Dr. Frank H. Lahey.

AT Bryn Mawr College, Professor Charlotte A. Scott has retired; she is succeeded as head of the department of mathematics by Professor Anna J. Pell. Dr. D. V. Widder has been appointed associate in mathematics.

A. E. MURNEEK, graduate student at the University of Wisconsin, has been appointed assistant professor of horticulture at the University of Missouri College of Agriculture. Mr. Murneek will finish his work for the Ph.D. degree about February 1.

DR. ROBERT L. PENDLETON, director of agriculture in Gwalior State, India, has been appointed professor of soil technology at the University of the Philippines, and in charge of the work in soils in the department of agronomy.

GRENVILLE B. FROST has resigned from the research department of the American Cyanamid Company, New York, to become lecturer in physical chemistry at Queen's University, Ontario.

DR. W. H. WOOD, lecturer in the University of Manchester, has been appointed to the Derby chair of anatomy in the university.

DISCUSSION AND CORRESPONDENCE

THE NUMBER OF BROTHERS AND SISTERS OF SELECTED INDIVIDUALS

SAYS Galton in his "Hereditary Genius" as quoted by Cattell ("American Men of Science," 1921, p. 804): "I also have found the (adult) families to consist on the average of not less than 2½ sons and 2½ daughters each. Consequently, each judge has on the average 1½ brothers and 2½ sisters." Cattell points out that this conclusion, obvious as it may appear at first sight, is really incorrect, since, with numerical equality of the sexes, boys should have, on the average, no more sisters than brothers. Rietz has recently (SCIENCE, LX, p. 46, July 11, 1924), given a mathematical generalization of the situation.

The phenomenon is due to the fact that more than one propositus may be picked from a single family, with the result that in ordinary statistical treatment of data some brothers and sisters are counted more than once. It is this point that Galton seems to have overlooked. For example, in his average family of 2½ sons and 2½ daughters it is apparent, if we designate the sons as A, B, and $\frac{C}{2}$ that A has 1½ brothers, 2½ sisters, and that B also has 1½ brothers, 2½ sisters, while $\frac{C}{2}$ has 2 brothers, 2½ sisters; a statistical total of 5 brothers, 7½ sisters. This might seem to be ½ brother too many according to Galton or 2½ too few, according to Cattell. But what the computation really shows—apart from illustrating the method—is that it is not always possible to treat an average as if it were an array. When, however, account is taken of the laws of chance and the frequency of families with various sex ratios, it can be shown, as Cattell and Rietz have done, that if the data are treated in the way indicated, a boy should have, *on the average,* just as many brothers as sisters.

But since even Galton seems to have been somewhat careless about this matter, it may not be out of place to call attention to another caution that should be borne in mind when dealing with this sort of data. When special groups are considered, the numerical

relations which Cattell has pointed out may be artificially altered by a combination of the ordinary methods of collecting data with a differential sex incidence of the trait under investigation. Judges are prevailingly men rather than women, and it is only when adequate care is taken in the method of selecting those to be investigated that one may expect the data to show an equality in the number of their brothers and sisters. The point involved may be brought out by means of a simple paradigm. Let us imagine a population with numerical equality of the sexes, and a calling in which half the men but none of the women attain a certain distinction. The tabulation, in which B stands for brother, S for sister and ′ for distinction, shows the distributions for families of three. The first column indicates a random distribution in the whole population. The second column shows the families in which there is at least one member of distinction. This is the material which would be utilized if the investigator could obtain all the desired data. But it generally happens that only a selected portion of it is available and, when such is the case, families with two or three distinguished individuals are two or three times as likely to be located as those with only one. The third column shows the consequent probable distribution of family records if the data are collected in the usual way. The proportion of the sexes in the three groups is interesting. In the first column the sex ratio is 100 and each boy, distinguished or otherwise, has, on an average, as many brothers as sisters. In the second column the sex ratio is 164; boys as a group have an excess of brothers, but those of distinction have only as many brothers as sisters. In the third column, which probably most nearly represents the usual character of available data, the sex ratio is 200 and boys of distinction have 7 brothers to 5 sisters. The difference would be still greater if there were a hereditary factor also involved.

1 B′ B′ B′	1 B′ B′ B′	3 B′ B′ B′
3 B′ B′ B	3 B′ B′ B	6 B′ B′ B
3 B′ B B	3 B′ B B	3 B′ B B
1 B B B	———	———
6 B′ B′ S	6 B′ B′ S	12 B′ B′ S
12 B′ B S	12 B′ B S	12 B′ B S
6 B B S	———	———
12 B′ S S	12 B′ S S	12 B′ S S
12 B S S	———	———
8 S S S	———	———

Obviously, such an extreme case as this hypothetical one is not likely to be met, but similar cases of less degree do occur, as the writer can testify from his own experience. The purpose of this note is simply to call attention to the existence of certain factors which, when combined as they frequently are, may affect the important relation pointed out by Cattell and Rietz.

STANFORD UNIVERSITY, C. H. DANFORTH
CALIFORNIA

ENERGY VALUES OF FEEDS FOR CATTLE

THE net energy conception of Armsby, having been unanimously indorsed by the American Society of Animal Production, may fairly be considered a promising basis for research in nutrition. In this connection a remarkable bit of confirmatory evidence will be of general interest.

The writer and others have reported a rather extensive series of experiments with cattle at the University of Missouri. These included live weight maintenance trials and slaughter experiments. In reviewing this work in a forthcoming monograph of the American Chemical Society the writer has calculated the maintenance costs of the 27 beef cattle used from the feed consumption in the feed lot and energy values obtained in some of Dr. Armsby's calorimeter experiments. In some of these experiments a few of the Missouri cattle were fed the Missouri ration and the metabolizable and net energy in the ration were determined. Using these figures, the average maintenance cost of the 27 cattle is shown to be 6.09 therms of net energy per 1,000 pounds per day. From calorimeter experiments Armsby had derived a value of 6 therms. Such an agreement in maintenance costs, in spite of widely varying quantities of feed and relative activity of the animals, supports the validity of the net energy conception.

The writer has previously reported results with two beef steers showing that the percentage of the metabolizable energy consumed above maintenance which was recovered in the flesh and other body substance gained by beef cattle was practically identical with the percentage of net energy in the feeds. One steer showed a recovery of 53.4 per cent. of the metabolizable energy above maintenance while another recovered 52.5 per cent. According to the method of Armsby this ration contained metabolizable energy which was 55 per cent. available or net.

Taken together these two pieces of evidence are a striking confirmation of the net energy conception.

C. ROBERT MOULTON
INSTITUTE OF AMERICAN MEAT PACKERS
CHICAGO, ILLINOIS

THE TEACHING OF EVOLUTION

IN the New York *Times* of October 20, there is published a deliverance from Mr. Julian Huxley, of Oxford, in which he appears to me to have indulged in the light occupation of jumping to conclusions in a manner not characteristic of his illustrious grandfather, and to have made some rather sweeping state-

ments on the basis of an inadequate observation of facts. Speaking of American educational institutions, he says:

> In the state universities I found the professors ready to give their opinions freely on evolution, but in theological schools many of them were afraid to speak except with extreme caution.
>
> The United States is the only country in the world where the attempt is being made to split up science into sects. Apparently there is Methodist biology, Baptist biology, Catholic biology—a biology for every denomination. If a professor in a Methodist college teaches Baptist biology or just plain biology, he is dismissed.

These statements impress me as being very inaccurate and misleading. There is no doubt that in a very considerable proportion of the theological seminaries of this country the doctrine of evolution is held and taught as one of the great basic laws of the universe. There is a large number of "denominational colleges" in the country, including such institutions as Amherst, Bowdoin, Dartmouth, Wesleyan, Oberlin, De Pauw, Beloit, Knox, Lawrence, Grinnell, Carleton and Pomona, where the doctrine of evolution is taught in just as scientific a manner and with as great freedom as it is in the state universities.

It is true that there is a scientific biology and a "Bryanese biology," between which there is a struggle at the present time. But this is not a denominational conflict. There are colleges in the country in which the teaching of scientific biology is not permitted. But they can not be considered as representative American colleges, and they are not restricted to any one or two or three denominations.

As a matter of fact, it seems that the attack of Mr. Bryan, Mr. Norris and other leaders in the Fundamentalist movement, is directed more against the state universities than against the denominational colleges, and it is an open question whether the biologists in standard representative colleges do not have greater academic freedom than is enjoyed in a number of our state universities. The Fundamentalists have launched a well-organzed campaign to prohibit by law the teaching of scientific biology in state universities and other tax-supported institutions. This campaign is being prosecuted with greatest vigor in the southern and southwestern states and there is a strong propaganda of the same sort in several midwestern states. When the Ku Klux Klan shall have accomplished their present objectives of disfranchising the Catholics, suppressing the Jews and Negroes and restoring the Bible to the public schools, they may logically be expected to "come over into Macedonia" and aid the Fundamentalists in their fight on scientific biology.

While biologists are not divided as to the fact of evolution, there are two or perhaps three schools of thought among them in regard to the definition of life, *viz.*, the mechanists, the vitalists, and the ignoramuses, sometimes called "agnostics." But here again the line of cleavage is not between the denominational colleges and the universities. There is a considerable number of eminent biologists, connected with some of our most distinguished universities, who do not find in physics and chemistry an adequate explanation of life—that "unknown god whom we ignorantly worship."

R. C. MULLENIX

LAWRENCE COLLEGE,
APPLETON, WISCONSIN

PERAMBULATING MILLIPEDS

I WAS inclined to doubt the identification of the myriapods referred to in "A note on migration of myriapodia," which appeared in SCIENCE, July 25, 1924, but O. F. Cook's note on the "Swarming of desert millipeds" (SCIENCE, September 26, 1924), clarifies the matter to my satisfaction.

My own observations on Louisiana myriapods may be of some interest in this connection. Centipedes, of course, of which we have several genera and species in Louisiana, are predaceous nocturnal creatures, and being cannibalistic when occasion permits are not inclined to gregarious habits. I have never seen them abroad in the daytime except when their haunts are disturbed, when they scurry individually to places of safety.

This is not so in the case of our millipeds, which may be seen abroad both day and night on suitable occasions, although all species seem to shun direct sunlight, and may remain hidden both day and night during hot, dry weather. Those individuals or species living in well-shaded woodlands can be most constantly encountered during the daytime. Day or night, however, all Louisiana species exhibit perambulatory habits after a rain and to a lesser extent during foggy weather.

The most conspicuous swarming I have observed in this state was in the case of *Actobolus* (*Spirobolus*) *marginatus*, a notably gregarious species normally inhabiting damp woods, where it feeds largely on decaying wood. About twenty years ago a section of cut-over cypress swampland lying between New Orleans and Lake Ponchartrain was reclaimed in order to develop the suburb now known as Lakeview. This milliped became abnormally abundant in that section about fifteen years ago and remained so for several years because of the decaying of the cypress stumps upon exposure to the weather after drainage. Every damp night during the late summer and after every rain, they could be seen crossing the roads in count-

less numbers, all uniformly sized adults, the majority traveling in a direction away from the center of greatest abundance, though not necessarily north. Because of these migrations, they soon populated newly reclaimed areas as fast as conditions became suitable.

In alluvial lands, it is easy to explain the value of the migratory habit to the species. Normally inhabiting the damp woodlands of low elevation immediately bordering the cypress swamps, the locality most suitable to them varies with periods of rainfall, floods and drouth. After they have taken to the swamp during a dry period, a rapid unindirectional migration is their only salvation from a sudden rise of the water level. The instinct to flee to higher ground after a rain urges them on even in permanently drained land.

I might hazard the following in explanation of the northerly course of the New Mexico species. Driven from their haunts in the burrows of desert rodents by excessive moisture from a passing storm, upon emerging at the surface of the ground they were unable to face the noonday sun and naturally looked to the northern sky for relief.

PERCY VIOSCA, JR.

RESEARCH DEPARTMENT,
SOUTHERN BIOLOGICAL SUPPLY CO., INC.,
NEW ORLEANS, LOUISIANA

SCIENTIFIC BOOKS

The Intellectual Worker and His Work. By WILLIAM MACDONALD. The Macmillan Co., 1924, pp. 351.

THE thesis of this book is that intellectual work will never be developed and supported as it should by the public until the intellectual workers exert themselves through cooperative organization to secure the recognition which is justified by their service to society. It is assuredly anomalous, as the author suggests, that a gifted class often best fitted by native endowments and special training to assist in the solution of public problems should be practically ignored by legislators and public alike. On the one side has grown up capital, and on the other organized labor, both influential and unafraid. In the twilight zone between stands the intellectual worker, for the most part mute and lacking power even to secure a minimum of protection to himself and his work. This is the more unfortunate because the bringing to bear of intelligence on environment, the special function of the intellectual worker, is responsible for the extraordinary development of our civilization. The very existence and progress of capital and manual labor depend, in final analysis, on the proper support and recognition of the intellectual worker. Without his continuing contribution a retrogression of society, which would wipe out the profits of capital and the wages of labor, would be immediate and inevitable.

MacDonald points out that the intellectual worker, since he lives from wages and not from profits, is economically aligned much more nearly with labor than with capital. Referring to the generally better pay of the manual laborer as compared with the brain worker, the author notes that the supposititious dignity which is presumed to atone for low salaries of intellectual workers is merely a cloak for wholesale exploitation of the group, with consequent underpayment and inevitably lowered standard of living. The true dignity is that of the manual laborer, who, through organization, has secured something of the recognition which is his due.

Attempted control of the opinions and activities of the intellectual worker, as by governing boards of universities through the immediate agency of the president, comes in for effective and strenuous protest at the hands of the author. The low state of intellectual work in some of the colleges of this country is indicated by the fact that active participation in politics may bring official rebuke, and often the only opinions on politics, religion or morals it is safe for a professor to express are those which accord with those of the corporation and the president. Support of a minority or third party still exposes a professor to discrimination and possible removal, and the holding of opinions officially branded as revolutionary is likely to put the teacher's tenure in jeopardy. Here is a situation, which, if continued, threatens democratic government. Progress everywhere has come as the result of some heresy. It is true enough that a certain amount of restraint is frequently necessary to promote harmonious and orderly civilized existence, but, as MacDonald naïvely remarks, the intellectual worker has the same right as the machinist, the bookkeeper or the unskilled laborer to the control of his leisure hours, to his opinions and their expression, and to the legal and political privileges which society accords in general to all its citizens. Highly illuminating is the author's reference to attempted governmental control of political opinions of professors in France, where, as he explains, an attempt to coerce the members of university faculties met with an unexpected check. In July, 1922, the dean of the Faculty of Letters at Paris, M. Ferdinand Brunot, who had publicly opposed a pending government proposal for the reform of secondary education which had aroused widespread discussion in intellectual circles, was called to account by the minister of public instruction. Professor Brunot at once replied:

> I have the right and duty to discuss these questions publicly where I please, as I please, and as much as I

please, and I am not required to furnish any justification for so doing.

The reply brought an official rebuke, to which Professor Brunot retorted:

> I am unable to take any engagement to make any concession whatever regarding the right which I have to defend, with entire freedom, what I believe to be the truth and the public interest. I consider that there is at this point an obligation of conscience which dominates everything else.

The author's treatment of the intellectual worker in the government service is scarcely adequate. Many of his criticisms of existing conditions are only too well known to government men; but he apparently fails to recognize that in the United States at least the scientific personnel of such branches as the Bureau of Standards, Geological Survey, Forest Service, Bureaus of Plant Industry, Entomology, Biological Survey and others is second to none in breadth of field, personal interest, initiative and accomplishment. Government work at its best sets the highest standards. We must, of course, learn to do all government work better, for it seems inevitable that the profiteers in every country will force governments to take over more and more of the development of great common natural resources, and the provision of essential industrial, social and scientific services.

Many will agree with MacDonald in his opinion that the status as citizens of civil servants who are intellectual workers should be better defined. Referring to the abridgment, in more than one country, of the right of civil servants to participate as citizens in the political life of the nation save as partisan supporters of the government in power he asserts:

> There is no social safety in such a course. The highest welfare of the state requires that every government employee should be accorded the same rights as any citizen to profess opinions, to support recognized political organizations, to offer himself as a candidate for elective office and to agitate for reform. In so far, indeed, as an intellectual worker in government employ is better educated or possesses greater natural abilities than the mass, the obligations of active citizenship are stronger with him than with others; for the duty of public service increases with ability, and from him to whom much has been given much is required.

The only concern of the state should be to insure that the worker's official duties are properly performed.

In view of the author's unusual clarity of vision regarding intellectual work as a whole it is surprising that his discussion of research (pp. 115–121) should be so disappointing. The importance of research, while referred to in general terms, is not stressed as it should be. Furthermore, he implies that in general the field of research tends to narrow as the range of human knowledge broadens. Precisely the opposite seems to the reviewer to be the case. As human knowledge broadens, the field of research tends ever to expand, promising more of inspiration, enjoyment and abundant life to all mankind.

With MacDonald's emphasis on the fundamentally important character of intellectual work and the desirability of securing better conditions for the work and the worker there can be little disagreement. As to methods to be employed to secure the desired betterment there may be some difference of opinion. There is no doubt, however, that scientific men and intellectual workers generally are adopting the view that only through active organized cooperation for economic advancement can the distressing disabilities now laid on the group be removed and a proper proportion of money, recognition and respect given to it.

The trend of the times is shown by a study of the organizations already in the field. The type of organization which is most in favor, as MacDonald points out, is one which, if not actually a trade union, has in general the strong professional solidarity and practical aggressiveness of such a body. A preliminary and incomplete list of organizations of intellectual workers, compiled late in 1922 by the International Labor Office, shows 389 such organizations exclusive of national or international federations, in 25 countries. Organizations affiliated with national federations totalled 256, making a grand total of 645 organizations in 27 different countries. France has led in the federation plan, with the associations known as the Compagnons de l'Intelligence and the Confederation des Travailleurs Intellectuels. The latter is made up of 83 societies representing nearly every intellectual occupation in France and embracing (Nov., 1922) approximately 185,000 members. The announced object of the confederation is common action for the protection of the rights and interests of all intellectual workers. Two groups of members of parliament, one of 133 members in the Chamber of Deputies and one of 90 members in the Senate, have been formed to protect, in union with the confederation, the interests of all intellectual workers in all matters of legislation pending before the chambers. National federations similar to the French Confederation have been formed in Belgium, Italy, Switzerland, Roumania, Austria and other countries. "There is only one conclusion to be drawn," says MacDonald. "The organization of intellectual workers has passed from the plane of theory or speculation to that of fact, and the movement has taken the world for its parish."

In a civilization dominated by ideas, it seems cer-